EXHIBIT A146

science for a changing world

Some Facts About Asbestos

This Fact Sheet briefly reviews what asbestos is, how it is identified, where it is found, and how it is used. The U.S. Geological Survey (USGS) provides information on asbestos geology, mineralogy, and mining; other agencies listed on page 4 provide information on regulations and health effects of asbestos exposure.

What is asbestos?

Asbestos is a generic name given to the fibrous variety of six naturally occurring minerals that have been used in commercial products. Asbestos is made up of fiber bundles. These bundles, in turn, are composed of extremely long and thin fibers that can be easily separated from one another. The bundles have splaying ends and are extremely flexible.

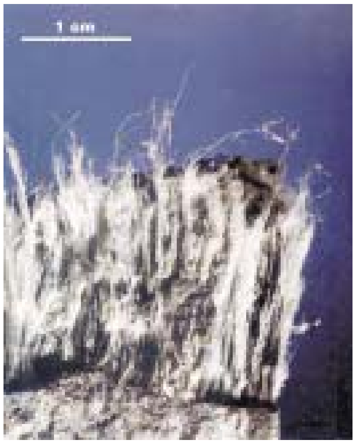
The term "asbestos" is not a mineralogical definition. It is a commercial designation for mineral products that possess high tensile strength, flexibility, resistance to chemical and thermal degradation, and high electrical resistance and that can be woven.

What minerals occur as asbestos?

The minerals that can crystallize as asbestos belong to two groups: serpentine (chrysotile) and amphibole (crocidolite, amosite, anthophyllite asbestos, tremolite asbestos, and actinolite asbestos). Amphiboles are distinguished from one another by the amount of sodium, calcium, magnesium, and iron that they contain. Serpentine and amphibole minerals can have fibrous or nonfibrous structures (fig. 1); the fibrous type is called asbestos (see sidebar on Serpentine and Amphibole Crystal Structure and Shape).

Asbestiform varieties of several other amphiboles have been identified. Other minerals are similar to asbestos in their particle shape, but they do not possess the characteristics required to classify them as asbestos (see definition of asbestos above).

A



B

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D

Figure 1. *A,* Chrysotile asbestos, a member of the serpentine group of minerals. *B,* Antigorite and lizardite, nonasbestiform serpentine minerals. *C,* Tremolite asbestos, a member of the amphibole group. *D,* Tremolite having a nonasbestiform habit. Serpentine and amphibole minerals can have fibrous or nonfibrous structures; the fibrous type is called asbestos. Photographs by Garrett Hyde from U.S. Bureau of Mines Information Circular 8751, 1977.

How is asbestos identified in a mineral sample or product?

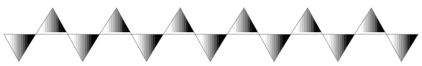
The best way to identify asbestos is to use a microscope to examine samples that have not been ground. Even with finely ground samples, there is no problem identifying chrysotile because its particle shape is distinct from the nonasbestiform varieties of serpentine.

With amphiboles, however, the distinction between asbestiform and nonasbestiform varieties is much less clear when examining samples through a microscope. The reason is that amphibole particles have a spectrum of shapes from blocky to prismatic to acicular to asbestiform. Also, amphiboles break (or cleave) into smaller fragments when finely ground. Long, thin cleavage fragments resemble asbestos fibers.

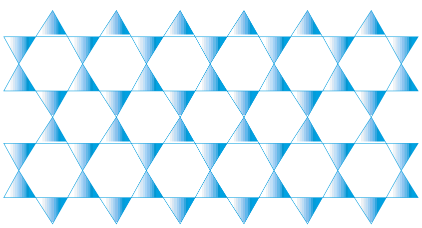
To resolve this problem, the analyst can compare the shapes of *several hundred* amphibole particles in the sample with those of asbestos reference materials and determine whether a sample is asbestiform with a fair degree of certainty. However, unless a fiber bundle has splaying ends, it is impossible to determine if a *single* long, thin particle grew that way (as asbestos) or is a cleavage fragment (nonasbestiform).

SERPENTINE AND AMPHIBOLE CRYSTAL STRUCTURE AND SHAPE

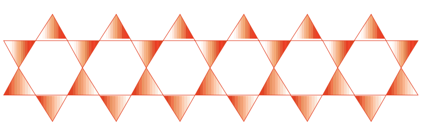
The frameworks of silicate minerals are composed of oxygen and silicon. These elements are arranged in the shape of a pyramid or tetrahedron, with silicon in the center and oxygen at the four corners. For many silicate minerals, these tetrahedra are arranged in rows, and the rows are repeated to form the crystal structure.



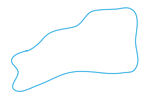
In serpentine, the element magnesium is coordinated with the oxygen atoms in the tetrahedra. The tetrahedra are arranged to form sheets. Serpentine is a sheet silicate.



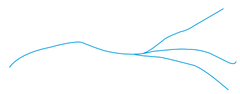
The framework for all amphiboles is a double chain composed of two rows of tetrahedra aligned side by side. Attached to these tetrahedra are elements such as aluminum, calcium, iron, magnesium, potassium, and sodium.



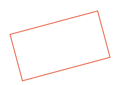
Among the three principal serpentine minerals, the distinction between asbestos and nonasbestiform varieties is apparent. In the nonasbestiform antigorite and lizardite, the silica tetrahedra are arranged to form a sheet structure, and the crystals are platy; that is, they have one short dimension and two longer, approximately equal dimensions, like a saucer.



In the asbestiform variety of serpentine, chrysotile, sheets are rolled up tightly to form fibers.

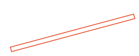


With amphiboles, the distinction is not so clear. When short double chains are arranged side by side, blocky or equant crystals form.

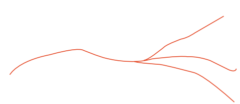


If growth is along the length of the double chains, rather than across their width, the amphibole crystals will be longer relative to their width. Slightly elongated crystals are prismatic.

As the length increases relative to the width, the crystals are called acicular.



When the length is extremely long compared with the width, the crystals are called asbestiform or fibrous.



Unlike serpentine, which is either nonasbestiform (platy) or asbestiform (fibrous), amphiboles have a gradational transition from blocky to prismatic to acicular to asbestiform. This gradational change makes it difficult to distinguish between asbestiform and nonasbestiform amphibole particles under the microscope.

Does it matter whether an amphibole is asbestiform when it comes to health risk?

Yes, the Occupational Safety and Health Administration (OSHA) conducted a review of the health effects of inhalation of nonasbestiform amphiboles. The agency determined (Federal Register, v. 57, no. 10, June 8, 1992, p. 24310) that “available evidence supports a conclusion that exposure to non-asbestiform cleavage fragments is not likely to produce a significant risk of developing asbestos-related disease.”

Breathing high levels of asbestos fibers for a long time can lead to an increased risk of asbestosis, lung cancer, and mesothelioma. Asbestosis is a noncancerous lung disease related to scarring of the lungs. This disease occurs in people heavily exposed to asbestos in the workplace and in household contacts of asbestos workers. Lung cancer is a relatively common form of cancer, which has been linked to smoking and a variety of occupational exposures. Cigarette smoking significantly increases the risk of lung cancer for people exposed to asbestos. Mesothelioma is a rare cancer of the membranes lining the lungs, chest, and abdominal cavity. Almost all cases are linked to occupational asbestos exposure. The symptoms of these diseases do not usually appear until 20 to 30 years after the first exposure to asbestos.

Particle shape, particle solubility, and duration of exposure are reported to be the three most important factors that determine lung damage. Many researchers believe that amphibole asbestos particles pose a greater risk than chrysotile particles because they are less soluble and more rigid than chrysotile, allowing the amphibole asbestos particles to penetrate lung tissue and remain longer.

What is the most common type of asbestos?

Chrysotile is the most common type of asbestos in the United States and the world.

What types of asbestos are mined?

Currently, chrysotile is the only type of asbestos mined on a large scale. It makes up over 99 percent of present-day production in the world. Only chrysotile is mined in the United States. In 1999, one firm in California accounted for all U.S. chrysotile production.

Small amounts of tremolite asbestos are mined in India and possibly a few other countries, but production is very limited. Commercial production of crocidolite and amosite ended about 4 years ago in South Africa. Anthophyllite asbestos has not been mined for an even longer period of time in the United States.

Where does U.S. asbestos occur?

Asbestos has been identified in 20 States (fig. 2) and mined in 17 States over the past 100 years. It is found in many common rocks. Serpentinite, the most widely occurring host rock for chrysotile, is present throughout the Appalachians, Cascades, Coast Ranges of California and Oregon, and other mountain belts.

In general, chrysotile and amphibole asbestos varieties occur in areas where the original rock, under elevated temperatures and pressures, has been changed by heated fluids (a process referred to as metamorphism). This type of altered rock occurs predominantly along the eastern seaboard from Alabama to Vermont, along the western seaboard from California to Washington, and in the upper Midwest in Minnesota and Michigan. Small occurrences of asbestos are in other areas, such as Arizona, Idaho, and Montana.

Although asbestos can be present in most of the metamorphic rocks described above, the bulk of the rock mass does not contain asbestos. In fact, most commercial asbestos deposits contain less than 6 percent asbestos by volume. Only a few deposits contain 50 percent or more asbestos (such as chrysotile deposits near Coalinga, Calif.).

Is asbestos still used in the United States?

Yes, about 15,000 metric tons (t) of asbestos was used in the United States in 1999; most was imported from Canada. Major manufacturing uses in the United States are as follows: asphaltic roofing compounds used on commercial buildings, 61 percent; gaskets, 19 percent; and friction products, such as brake shoes and clutches, 13 percent. Most of these products are installed on a commercial basis under conditions regulated by OSHA. Although very few asbestos products have been banned in the United States, there are almost no asbestos-containing products manufactured specifically for use by the general public.

Figure 2. Occurrences of asbestos in the contiguous United States. Major asbestos-bearing deposits occur in the mountain belts in the Eastern and Western United States. Data from USGS Digital Data Series DDS–52 (E.J. McFaul and others, 2000, U.S. Geological Survey Mineral Databases—MRDS and MAS/MILS).

Is 15,000 metric tons a lot of asbestos?

Relatively speaking, no. The peak year of asbestos use in the United States was 1973, when approximately 719,000 t of asbestos was used for manufacturing friction products, flooring, caulks, gaskets, packings, electrical and heat insulation, plastics, roofing, textiles, and a host of other consumer and commercial products.

There have been thousands of applications for asbestos. Most were viewed as practical solutions to difficult problems. For instance, asbestos helped make the braking systems in automobiles much more dependable, it enabled the production of inexpensive cement-based water-supply pipes, and despite the dire consequences to the installers, asbestos insulation made the warships of World War II much safer.

In the late 1960's and early 1970's, the consumption of asbestos increased at the rate of 3 to 4 percent annually. In the 1980's and 1990's, consumption declined 5 percent annually (fig. 3).

What caused the decline in asbestos use?

Concerns over health risks posed by high exposures to airborne asbestos brought on much of the decline. From the 1970's onward, public pressure to reduce exposure to asbestos resulted in lowered exposure standards and spurred the quest for alternatives to asbestos. Exposure standards were reduced from 5 fibers per cubic centimeter (f/cc) of air over an 8-hour time period to 0.1 f/cc in the workplace. Also, spraying of asbestos insulation onto steel girders and consumer sales of raw asbestos and artificial fireplace logs containing asbestos were banned. Commercial products such as asbestos-containing insulations, plasters, ceiling tiles, cement products, and caulks were slowly phased out. Many companies ceased production of asbestos products because of liability issues. As a result, asbestos consumption in the United States declined rapidly.

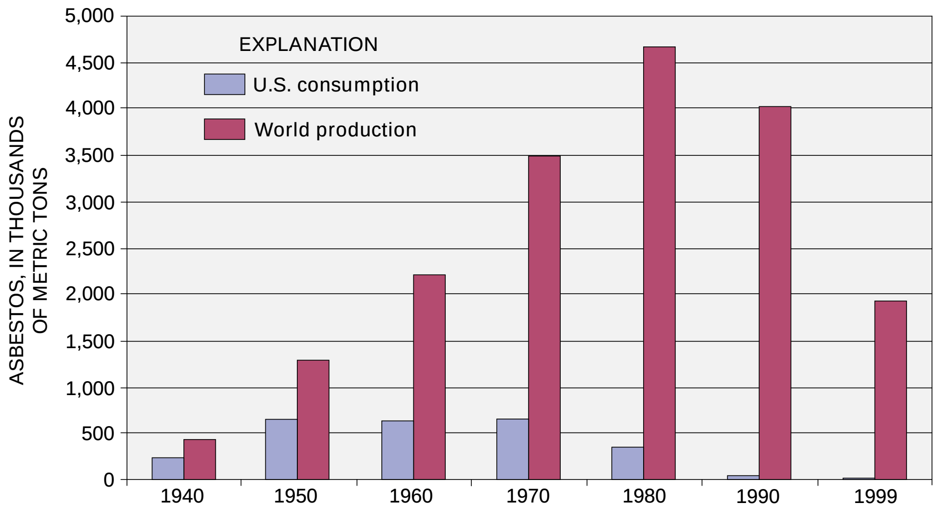


Figure 3. Asbestos consumption in the United States and world production of asbestos, which is used as a guide to world consumption. Peak U.S. consumption of asbestos was 719,000 metric tons in 1973. Peak world production was 5.09 million metric tons in 1975. Data from Minerals Yearbook, v. I (published by the U.S. Bureau of Mines until 1995 and by the U.S. Geological Survey after 1995).

What about worldwide use of asbestos?

Worldwide, the use of asbestos has declined, particularly in Western Europe. Asbestos production is used as a rough guide for consumption (fig. 3). Production declined from 5.09 million metric tons (Mt) in 1975 to about 1.93 Mt in 1999. Several Western European countries have banned some or all asbestos products.

In other regions of the world, there is a continued demand for inexpensive, durable construction materials. Consequently, markets remain strong for asbestos-cement (A/C) products, such as A/C panels for construction of buildings and A/C pipe for water-supply lines.

What is the connection between asbestos and vermiculite?

The connection between asbestos and vermiculite was first brought to public attention recently because of a vermiculite mine near Libby, Mont. Vermiculite consists of clay minerals that expand when heated to form wormlike particles. Vermiculite is used in concrete aggregate, fertilizer carriers, insulation, potting soil, and soil conditioners.

The Libby mine opened in 1921 and once accounted for almost 80 percent of the world's vermiculite production. The Libby deposit is unique among commercial U.S. vermiculite deposits in having an average amphibole asbestos content of 4 to 6 percent. Miners and millers were, at times, exposed to high levels of asbestos-containing dusts. Many workers developed health problems as a result of those exposures. Some residents of Libby who were exposed to high levels of asbestos also have been diagnosed with asbestos-related symptoms.

Officials are concerned about the asbestos content of the soils around Libby, about workers who processed the Libby vermiculite ore in manufacturing plants scattered throughout the United States, and about the customers of those plants. USGS scientists are using a hyperspectral remote-sensing survey of Libby to help map the distributions of the asbestiform amphiboles in soils.

Is this vermiculite still being sold?

The Libby vermiculite mine closed in 1990, and shipments of vermiculite from the Libby mill site ended in 1992. However, products made from the Libby vermiculite may still be available from retailers who sell from old stocks. The only certain way to know whether vermiculite came from the Libby mine is to ask the manufacturer.

Is more information available on asbestos?

Yes. For questions concerning geology, mineralogy, and the asbestos industry, contact the U.S. Geological Survey online at http://minerals.usgs.gov/minerals or by fax from Mines FaxBack at (703) 648–4999.

For information on regulations and health effects of asbestos exposure, contact these agencies online:

- Consumer Product Safety Commission (www.cpsc.gov)
- U.S. Environmental Protection Agency (www.epa.gov)
- Mine Safety and Health Administration (www.msha.gov)
- Occupational Safety and Health Administration (www.osha.gov)
- National Institute for Occupational Safety and Health (www.cdc.gov/niosh/)
- National Institutes of Health (www.nih.gov)

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